RESISTANCE ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] This invention relates to a resistance assembly for use in an exercise machine.

[0002] Exercise machines make use of diverse devices such as free weights, weight plates, elastic bands, springs and the like to provide a resistance force against which a user can exercise. It has been found that, in many of these machines, the stroke length, which is the distance against which a user moves his arms or legs, as the case may be, against a resistive force, must be reasonably long and this, in turn, means that an exercise machine must also be of substantial dimensions.

[0003] It is preferable to have a substantially constant resistance force, against which a user exercises, over the stroke length. If use is made of a spring or similar component, to provide the resistance force then, as is known, the spring characteristic is such that the resistance force increases more or less linearly with spring deformation. In other words the more the resistance device is moved the greater is the resistance force which acts against movement from the user. This is not necessarily a desirable characteristic.

[0004] If one or more weights are used to provide the resistance force then a substantially constant resistance force is obtained over the stroke length. When a user who is physically strong makes use of the exercise

machine then the number of weights which must be provided is substantial and this carries with it a penalty in that the exercise machine is then not necessarily easily transportable and, inevitably, the exercise machine is cumbersome and expensive to ship to a customer.

[0005] Another factor is that the positive resistance force, which is the resistance force displayed by the resistance device when energy is put into an exercise machine by a user, should, as far as is possible, be the same as the negative resistance force which results when energy which is stored in the exercise machine is released, on a return stroke. These forces can only be matched to one another, at least to some extent, if frictional and similar losses are minimised.

[0006] It should be possible, particularly for a device which is intended for a home user, to be able to adjust the resistance force, exhibited by an exercise machine, with relative ease. The exercise machine should, as noted, be compact and light so that it is suited for easy storage and transport. It is also desirable to be able to use the machine in one of at least two modes eg. by working against a resistance force by pulling downwardly on an actuator which may be of any suitable form eg. a handle, a bar, an ankle or wrist cuff, or the like, or by working against a resistance force by pulling upwardly on an actuator. These modes are given merely by way of example for the exercise machine could be constructed to provide the resistance force against other types of movement eg. a pushing or a rotating movement by the user.

SUMMARY OF INVENTION

[0007] The invention provides a resistance assembly for use in an exercise machine which includes an elongate first cylinder with a first cross sectional area, an interior of the first cylinder, in use, being pressurised with a gas, an elongate member with a first end and a second end, the elongate member extending partly into the interior of the first cylinder with the first end inside the first cylinder and the second end outside the first cylinder, the elongate member being mounted for reciprocating movement, in its longitudinal direction, relatively to the first cylinder, the elongate member upon being moved by a distance ℓ into the interior of the first cylinder displacing a volume of gas which is given by the expression ℓ x a where a is a second cross sectional area which is smaller than the first cross sectional area, and a formation at a location selected from a position on the elongate member which is outside the first cylinder and a position on the first cylinder for connection to an actuator whereby a user can cause movement of the elongate member relatively to the first cylinder.

[0008] The resistance assembly may include apparatus for pressurizing the interior of the first cylinder with a gas.

[0009] In one embodiment the elongate member is tubular with a hollow interior and the first end is open and in communication with the interior of the first cylinder, and the second end is sealed.

[0010] Preferably the cross sectional area of the hollow interior is equal to the second cross sectional area.

[0011] In a second form of the invention the elongate member has a cross sectional area which is equal to the second cross sectional area.

[0012] In this form of the invention the elongate member may be solid or, if tubular, its inner end is sealed.

[0013] The assembly may include a piston head, with inner and outer sides, which is fixed to the first end of the elongate member and which is engageable with an internal surface of the first cylinder and which acts to guide the reciprocating movement of the elongate element and wherein, within the interior of the first cylinder, the pressure of the gas on the inner side of the piston head is the same as the pressure of the gas on the outer side of the piston head.

[0014] The piston head may include at least one formation which allows for free movement of gas, inside the interior of the first cylinder, between the inner side of the piston head and the outer side of the piston head.

[0015] The at least one formation may be a passage in the piston head between the inner side and the outer side thereof.

[0016] In another form of the invention the resistance assembly includes a second cylinder which is located at least partly within the first cylinder and

which includes an inner end through which at least part of an interior of the second cylinder is placed in gas communication with the interior of the first cylinder and an outer end, the elongate member extending partly into the second cylinder with the first end of the elongate member inside the second cylinder and the second end of the elongate member extending from the outer end of the second cylinder, the reciprocating movement of the elongate member taking place inside the second cylinder, and a piston head at the first end of the elongate member which is in sealing and reciprocating contact with an opposed inner surface of the second cylinder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The invention is further described by way of examples with reference to the accompanying drawings in which:

Figure 1 is a side view of an exercise machine which includes a resistance assembly according to the invention, in a ready-to-use state;

Figure 2 is a perspective view from the front of the machine with certain components removed to simplify the illustration;

Figure 3 illustrates moving components of the exercise machine of Figure 1;

Figure 4 illustrate a different type of resistance assembly to what is employed in the machine of Figures 1 to 3;

Figure 5 shows another type of resistance assembly, according to the invention, and

Figure 6 schematically depicts a prior art type of resistance assembly.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0018] Figures 1 to 3 of the accompanying drawings illustrate an exercise machine 10 which uses a resistance assembly according to a first form of the invention.

[0019] The exercise machine includes a frame 12 to which is attached a seat 16 on which a user can be seated, and a backrest 18 for the back of a user positioned on the seat. For storage and transport purposes the seat 16, which is normally braced by one or more stays 20, can be folded downwardly so that it is substantially parallel to the frame while, in a similar fashion, the backrest 18 which is braced by one or more stays 22 can be pivoted towards the frame to take up a compact position. A structure 24 can be used at an upper end of the frame as a holder for a card which carries information on exercise sequences particularly if the backrest is moved to a compact storage position adjacent the frame.

[0020] The frame is supported at an inclined position relatively to the ground 26 by a downwardly depending U-member 28 which is attached at a pivot point 30 to brackets 32 on a rear side of the frame 12. The U-member 28 can be moved inwardly towards the frame 12 for storage and transport purposes or, as is shown in Figure 1, can be moved away from the frame to provide a maximum degree of stable support for the frame.

[0021] The exercise machine includes a footpiece 36 at a foot of the frame. The footpiece forms a housing in which are located an electric motor

38 and an air pump or compressor 40 which is driven by the motor and which delivers air via a flexible pipe 42 to a cylinder 44 which is supported by the frame 12.

[0022] An upper surface 46 of the footpiece housing is serrated or roughened and provides a reactive surface against which feet of a user, positioned on the seat, react.

[0023] A flexible electric cord 50 extends from the motor to a main electrical supply point, not shown. A switch 52 on the footpiece 36 can be actuated by a foot of a user to connect the motor 38 to the main supply or turn the electrical supply off. In this way the operation of the motor 38 can be controlled. A pressure relief valve 60 is connected to the cylinder 44 via a flexible line 62. The pressure relief valve can also be operated by means of a foot of a user. Thus it is possible for the user to turn the compressor on and thereby pressurise the cylinder 44; turn the compressor off; or reduce the pressure inside the cylinder by actuating the valve 60.

[0024] The cylinder 44 is connected to a piston 70 to make up a resistance assembly 72, according to a first form of the invention, which provides a resistance force for a user. The manner in which this is achieved is described hereinafter. The cylinder 44 has a lower end 74 which is sealed and which is mounted to a lower wheeled carriage 76. The piston 70 has a piston head 78 which is mounted for reciprocating movement inside the

cylinder and a piston rod 80 which extends from the head. An upper end of the rod is mounted to an upper wheeled carriage 82.

[0025] A first pulley and cable system 84 is mounted to act on the lower carriage 76 while a second pulley and cable system 86 is mounted to act on the upper carriage 82. The system 84 includes a pair of handles 88A and 88B which are connected to each other by means of a cable 90 which passes over a succession of pulleys 92A to 92E respectively. The pulley 92C is connected to the carriage 76 by means of a cable 98 which passes over pulleys 100A and 100B on the carriage. An end of the cable 98 is attached to an anchor point 102 on the frame 12.

[0026] The system 86 has handles 108A and 108B respectively at a lower side of the frame which are connected to a cable 110 which passes over pulleys 112A to 112E respectively. The pulley 112C is connected to the carriage 82 by means of a cable 114 which passes over pulleys 116A and 116B which are mounted to the carriage. An end of the cable is tied to an anchor point 118 on the frame.

[0027] It is evident from Figure 2 that the piston head 78 acts only in a guiding capacity within the cylinder. The piston head is formed with a plurality of formations in the form of notches or cut-outs 120 which define passages through the piston head and consequently the pressure inside the cylinder on one side of the piston head is the same as the pressure on an opposing side of the head.

[0028] The piston rod 80 is tubular with a hollow interior 122. A plug 124 seals an upper end of the rod 80. A lower end of the rod, which is connected to the piston head 78, is open and forms a mouth 126 which places the interior of the cylinder 44 in communication with the hollow interior of the rod.

[0029] When the exercise machine is to be used the frame 12 is positioned so that it has the orientation shown in Figure 1. A user could be seated, kneeling or standing while exercising. Assume the user positions himself on the seat 16 with his back against the backrest 18. The user activates the switch 52 with one of his feet and the motor 38 is energised and then drives the compressor 40. Once the interior of the cylinder 44 has been pressurised to a desired air pressure the motor is turned off. If the pressure inside the cylinder is too high the pressure relief valve 60 is actuated to allow air to escape from the cylinder. It is therefore relatively easy for a user to adjust or control the pressure inside the cylinder using the foot-operated controls 52 and 60.

[0030] Assume that the user grips the upper handles 88A and 88B and pulls downwardly on the handles as is indicated by arrows 130 in Figure 3. Due to the pulley and cable system 84 the lower carriage 76 is elevated and the cylinder rises with the piston moving with a telescoping action into the cylinder. A resistance force is generated which tends to act against the aforementioned movement as the rod 80 is forced into the cylinder. The effective volume which is occupied by the pressurized air inside the cylinder

and the hollow piston rod 80 is reduced depending on the extent to which the rod extends into the cylinder 44.

[0031] If the pressure inside the cylinder 44 is relatively high then a significant force is needed to move the rod 80 into the cylinder. However as the volume of the interior of the rod 80 is comparatively small compared to the volume of the cylinder 44, the force which is needed to move the rod into the cylinder increases only slightly as the rod extends to a greater extent into the cylinder. In other words over the stroke length represented by the downward movement of the handles 88A and 88B, the resistance force displayed by the piston and cylinder assembly 72 increases only slightly.

[0032] Due to the mechanical advantage of the system 84 the stroke length of the handles 88A and 88B is four times the stroke length of the piston into the cylinder. Thus the piston and cylinder assembly can be relatively compact compared to the stroke length of the exercise machine. This carries a further benefit in that the change in pressure, inside the cylinder, as the assembly is telescoped is restricted because the extent of movement of the piston relatively to the cylinder is limited.

[0033] During the aforementioned telescoping movement of the assembly 72 the upper end of the piston rod is supported by the carriage 82 which in turn is supported by a bracing member or formation 140 on the frame 12. On the other hand when the handles 108A and 108B are gripped and pulled upwardly, in the direction of arrows 142, the upper carriage 82 moves

downwardly and the lower end 74 of the cylinder 44, which is mounted to the lower carriage 76, is prevented from moving by a support or bracing member 146 of the frame.

[0034] The handles 108A and 108B exhibit the same relatively long stroke length, compared to the stroke length of the piston into the cylinder, as the handles 88A and 88B.

[0035] The exercise machine 10 has a number of significant benefits. Firstly, it is possible for a user to adjust the pressure inside the cylinder 44 and this in turn means that the user can adjust the resistance force according to his physical condition even while exercising. The adjustment is done without the user needing to disengage his hands from the handles 88 or 108, as the case may be. Secondly, as noted, the stroke length which results when the handles 88 or 108 are used is four times the stroke length of the piston into the cylinder. This allows for a compact construction of the exercise machine.

[0036] Thirdly, the number of pulleys in each of the systems 84 and 86 is relatively low and this means that frictional losses are kept to a minimum. Consequently the positive resistance force displayed by the piston and cylinder assembly 72 (ie. the force which results when the handles 88 are moved in the direction of the arrows 130 or when the handles 108 are moved in the direction of the arrows 142) is only slightly greater than the negative resistance force which is the force produced when the air inside the cylinder

44 expands to restore the piston and cylinder assembly to its extended position.

[0037] A further benefit, already alluded to, is that the force which is needed to drive the piston rod deeper into the cylinder increases only slightly as the rod extends into the cylinder. This force is a function of the pressure inside the cylinder and if the pressure is sufficiently high the relative increase in the force, as the piston moves into the cylinder, is comparatively low. The extent to which the force increases is a function of the relative volumes of the cylinder 44 and of the interior of the hollow rod 80.

[0038] The exercise machine is lightweight. The resistance force results from the use of a cylinder and piston assembly which is pressurised with air by a user to a chosen, controlled level which is readily adjustable. The need for heavy weights is therefore eliminated. The exercise machine can be folded compactly into a fairly flat arrangement which can, for example, be stored under a bed or behind a door when not required. In this respect it should be observed that the compressor and motor are mounted in the housing 36 and are therefore integrally associated with the exercise machine. As is indicated by a curved arrow 158 in Figure 1 the housing can be folded upwardly to a compact storage position, adjacent the frame, when required. The exercise machine is thus a fully self-contained unit and only requires connection to an electrical supply to become operational. The same principles could however be employed to provide an exercise machine, which may be one of a plurality of similar machines, which is pressurized from a

remotely installed compressor. The pressure in each machine could then be controlled as required by each respective user.

[0039] In each case the controls could be foot-operated. However hand-operated, remotely activated, and voice actuated controls could also be used to regulate the pressure in the cylinder.

[0040] Figure 4 illustrates a resistance assembly 160, according to a second form of the invention, which can be used in place of the resistance assembly 72 shown in Figures 2 and 3. The resistance assembly 160 has a number of similarities to the assembly 72 and consequently, where appropriate, like reference numerals are used to designate like components. The assembly 160 is not shown installed in an exercise machine. It can be used in the same way as the assembly 72, as shown in Figures 1 to 3, or in any other exercise machine of appropriate design. A similar comment applies to the assembly 72.

[0041] The principal difference between the assembly 72 and the assembly 160 is that the piston rod, designated 80A in the assembly 160, is solid. Alternatively, if the rod is hollow, the lower end of the rod, designated 126A, is sealed by means of a plate or plug so that it is airtight.

[0042] The interior of the cylinder 44 is, as before, pressurized by means of a compressor or a gas cylinder.

[0043] The piston head 78 also has notches or cut-outs 120 which ensure that the pressure inside the cylinder on an upper side of the piston head is the same as the pressure on a lower side of the piston head.

[0044] When the piston rod is caused to move relatively to the cylinder (with the cylinder stationary) or if the cylinder is caused to reciprocate relatively to the piston rod (with the piston rod stationary) the air inside the cylinder is further pressurized as the rod 80A extends to a greater extent into the cylinder while the pressure is slightly reduced as the rod is retracted from the cylinder. The operation is substantially the same as for the resistance assembly 72 except that for the assembly 72 the maximum volume occupied by the pressurized air is equal to the sum of the volume of the cylinder and of the volume of the interior of the hollow piston rod while the minimum volume is equal to the volume of the cylinder minus the volume of the wall of the piston rod. With the assembly 160 the maximum volume occupied by the pressurized air is slightly less than for the assembly 72 and is equal to the volume of the cylinder. The minimum volume is also slightly decreased in that it is equal to the volume of the cylinder minus the volume of the solid or sealed piston rod. In substance however the resistance assembly 160 offers the same benefits as the resistance assembly 72.

[0045] Figure 5 illustrates a third resistance assembly 166 which is also equivalent to the assembly 72. The assembly 166 includes a first or outer cylinder 168 and a second cylinder 170 which is positioned inside the cylinder 168. A lower end 172 of the cylinder 170 is open and is supported by a plate

174 in which is formed a plurality of holes 176. An upper end of the cylinder 170 is supported by a plate 180 which is sealingly engaged with the cylinders 168 and 170 and which includes a hole or plug 182 through which a piston rod 184 extends. A leading end 186 of the piston rod carries a piston head 188 which is slidingly and sealingly engaged with an inner surface 190 of the second cylinder 170. An outer or upper end 192 of the rod 184 is engaged with carriage structure 82 on an exercise machine (not shown). Similarly a lower end of the cylinder 168 is attached to carriage structure 76 of the exercise machine. The resistance assembly 166 can for example be used in a manner similar to that shown in Figure 2 although this is by no means limiting for the resistance assembly can be used in an exercise machine of any appropriate design.

[0046] The cylinder 168 and the cylinder 170 are simultaneously pressurized with pressurized air from a suitable compressor or gas cylinder, not shown.

[0047] The piston head 188 performs the same function as the hollow rod 80 in Figure 2 or the solid rod 80A in Figure 4 for as the piston head 188 advances into the cylinder 170 the air in both cylinders is pressurized depending on the total volume of air which is displaced by the advancing piston head.

[0048] The situation which arises when the resistance assembly of the invention is used should be contrasted with the prior art situation shown

schematically in Figure 6 which illustrates a reservoir or accumulator 200 which is pressurized with air from an air source 202 eg. a compressor. A separate resistance cylinder 204 of relatively small construction is connected to the reservoir via a pipe 205. The cylinder 204 includes a piston rod 206 with a piston head 208 which is mounted for reciprocating and sealing movement inside the cylinder 204. As is evident from prior art documents exercise machines which make use of the prior art arrangement shown in Figure 6 are bulky for they require at least two separate cylinders. If the prior art arrangement is employed in an exercise machine then it is difficult to provide a compact exercise machine which, in an inoperative storage mode, is adapted for easy transport or storage. This specific objective is met by an exercise machine which makes use of a resistance assembly according to the invention.

[0049] With the resistance assemblies 72 and 160 the effective cross sectional area of the piston rod determines the volume of air which is displaced when the piston rod is moved into the cylinder. Referring to Figure 2 assume that the piston rod has a cross sectional area a in its hollow interior and that the cylinder 44 has a cross sectional area A. When the rod is moved into the cylinder by a distance ℓ the volume of air which is displaced is given by the expression $\ell \times a$. As the cross sectional area a is substantial less than the cross sectional area A of the cylinder 44 the change in pressure inside the cylinder is relatively small and to a substantial extent the piston moves against a force which does not increase significantly with piston rod movement.

[0050] In the Figure 4 embodiment the cross sectional area of the solid piston rod 80A is a and when the piston rod is advanced into the cylinder 44 by a distance ℓ the volume of air displaced is a x ℓ which, again, is substantially less than what would be case if the piston head 78 were large and were sealingly engaged with the cylinder 44.

[0051] In the Figure 5 embodiment the cross sectional area of the piston 188 is a and, when the piston is advanced by a distance ℓ into the cylinder 170, the volume of air displaced is given by the expression a x ℓ.

[0052] In all three embodiments if a is substantially less than the cross sectional area A of the cylinder 44 or the effective cross sectional area of the cylinder 168, as the case may be, then there is only a marginal increase in the resistance force as the piston is moved from a position at which it is fully retracted from the cylinder to a position at which it is fully inserted into the cylinder. Although it is possible with the prior art arrangement shown in Figure 6 to achieve a similar relatively small variation in air pressure this is at the expense of at least one additional space consuming component.

[0053] The ratio of A to a should be at least 6 but preferably is higher. In this respect a compromise must be struck between the resistance force which is generated (this is a function of the product of a and the air pressure force during a piston stroke.